Much has been learned about barrier installation

Since WSDOT placed the first cable median barrier on Washington highways in 1995, much has been learned about cable barrier. Because cable barrier is a relatively new countermeasure for cross-median collisions and has a unique design, it has received a great deal of scrutiny from transportation professionals and the traveling public.

As the level of experience with cable barrier systems has grown around the country, research institutions and product developers explored how to make the systems perform in new ways and in new applications. Recent product development efforts have led to system modifications and new designs aimed toward expanding the parameters of where cable barrier can be placed and the collision conditions where cable barrier may be effective.

Placement of barrier within the median is a factor

We have learned that placement of the barrier within the median has been identified as a factor in cross-median collisions for some vehicle types. Crash testing conducted by the Federal Highway Administration (FHWA) in 2004 revealed that cable barrier offset from, but in close proximity to, the bottom of the median ditch was allowing vehicles to pass under the cables. As a result of this testing, WSDOT modified its placement guidance for future cable barrier installations. Placement of cable barrier just below a slope-break was identified as a factor in a 2007 collision where the impacting vehicle went over the cable barrier. Design work is in progress to install a concrete barrier in the median at this location.

The cable attachment mechanism is another factor in cross-median collisions

The cable attachment mechanism for connecting the wire rope to other hardware components has also been identified as a potential factor in cross-median collisions. This issue has been observed only in low-tension cable barrier installations, which are currently installed along 43 miles of highway. There have been a few instances where the connecting mechanism allowed the cable to release from the tensioning hardware in a collision event. WSDOT has implemented a research project to develop an attachment mechanism that can be installed as a retrofit to existing systems. The results of that evaluation will be completed by the next annual report. High-tension cable barrier systems are currently specified by WSDOT for future installations.

An independent expert review of WSDOT's cable barrier was conducted in 2007

In February 2007, Gov. Chris Gregoire requested that WSDOT conduct an independent expert review of cable median barriers following the fatal cross-median collision on Interstate 5 in Marysville on Feb. 13, 2007. The evaluation included an examination of WSDOT's cable median barrier policy, statewide cable median barrier performance, and other cross-median collisions along a 10-mile stretch of I-5 in Marysville.

WSDOT hired Dr. Malcolm Ray, PE, Ph.D., to conduct an independent evaluation of our cable median barrier policy and program. His full report is included in the June 2007 "Cable Median Barrier, Reassessment and Recommendations" report. Dr. Ray's recommendations addressed cable barriers in Marysville, policies, and future research.

This following is a summary of WSDOT's activities and implementation status for those recommendations.

Status of recommendations

- **In Marysville**

  Replace the existing low-tension cable median barrier along the northbound side of I-5 with concrete barrier and maintain the existing high-tension cable median barrier along the southbound side of I-5.

  Update: WSDOT is designing a project to install concrete barrier along 10 miles of northbound I-5 in Marysville. (See Chapter 3 for more detail.)

- **Locations other than Marysville**

  Continue installation of cable median barrier.

  Update: At the end of 2006, WSDOT had installed approximately 135 miles of cable median barrier, with an additional 30 miles under construction. By the end of 2007, all of the 30 miles under contract were completed and 12 additional miles were installed. There were 3.5 miles of cable median barrier under contract at the end of 2007.

  Currently, there are plans to install another seven miles on full access controlled facilities by the end of 2008. There are also another 6.6 miles under contract or planned for partial controlled access facilities (non-freeway routes). All of the barrier installed in 2007 was high-tension cable barrier.

  WSDOT plans to remove approximately eight miles of cable median barrier as part of a widening project on I-5 from Grand Mound to Maytown. The project widens the freeway for an additional lane in each direction. The widening project will make the median narrower and as a result the cable barrier will be replaced with concrete barrier.

- **Cable median barrier installation and placement**

  Create procedures to install the cable-securing wedge in low-tension cable barrier systems.

  Provide additional dimensions of fabricated parts and materials specifications for low-tension cable barrier systems to design engineers.

  Improve the design of the cable-securing wedge in low-tension cable barrier systems.

  Update: These three recommendations are for improving the design of the low-tension cable barrier. WSDOT discontinued installing low-tension systems and therefore, improving this design is unnecessary. In addition, WSDOT has contracted with the Texas Transportation Institute to develop a retrofit design that would eliminate the tensioning hardware, including the "wedge" connection. If successful, this would eliminate some of the connection points that exist in the current design, and may allow longer runs between cable anchors. This project is underway and is expected to be completed in 2008. At that time, WSDOT will evaluate the priority of this work compared to other safety improvements.

- **Performance on slopes**

  Sponsor research to examine high-tension cable barrier performance on slopes and when struck by larger vehicles.

  Update: Research and testing is underway to investigate the performance of cable barrier on slopes. In 2007 a research project proposed by WSDOT was selected for funding as part of the National Cooperative Highway Research Program (NCHRP). This project, "Development of Guidance for the Selection, Use, and Maintenance of Cable Barrier Systems" (NCHRP 22-25), will investigate the optimum placement of cable barrier in median installations. A WSDOT employee is on the project panel and is helping steer the direction of this research. The research project will develop guidance on where to use cable barrier systems, how to connect to other barrier systems, and how to maintain cable barrier systems. Work on this project is scheduled for completion in July 2009.

  Studies being conducted at the National Crash Analysis Center (NCAC) at George Washington University are being done to investigate bumper trajectories in a range of departure angles (from the roadway) and speeds, on a variety of median slopes, in order to determine an optimum height for cables in barrier systems. These will provide data that help designers determine the proper height for top and bottom cables.

  In addition, there are efforts underway to develop barrier designs that can be installed on slopes in medians. In Lincoln Nebraska, the Midwest Roadside Safety Facility, a national leader in research and development of roadside safety hardware, has recently tested a new cable barrier design that was installed on 4H:1V slopes[1]. This design uses four cables and was tested with vehicles with higher bumpers, such as SUVs and pickup trucks. The four cables are spaced so that the bottom cable is lower and the top cable is higher than the cable barrier system designs that have been used in the past two years. This should help reduce the potential for vehicles to go under or over the barrier. While the tests appeared to be successful, the researchers are considering some modifications, and this barrier has not yet been installed on any highway facilities.

  Several cable barrier manufacturers have also tested their systems on 4H:1V slopes. Trinity Industries, the manufacturer of the primary cable barrier system used in Washington, is one of these. Trinity also conducted tests of their system on larger vehicles. The new design Trinity tested does not lend itself to retrofitting existing cable installations in Washington. This is due to the type of posts used in the new design; they do not fit in the sockets that exist in the field. As a result, retrofitting our existing barrier would be comparable to complete replacement.

  At WSDOT's request, Trinity is evaluating design changes that would be more practical (that use a similarly shaped post, for example). The results from this evaluation are expected by fall 2008.

- **Placing cable barrier on slopes**

  Until research examining high-tension cable barrier and slopes is complete, WSDOT will consider the following when placing cable barrier near the break point between 10H:1V and 6H:1V slopes in the median:

  - *For single-run cable median barrier placed at least 13 feet from the edge of the nearest traveled lane to the slope, place the barrier at least one foot before the slope breakpoint*
  - *For double runs, if there is at least 11 feet from the edge of the nearest traveled lane, place the barrier at least one foot before the slope breakpoint*

[1] 4H:1V refers to a slope ratio of four feet horizontal distance for each one foot of elevation change.

- *When there is not sufficient space to position the barrier before the slope breakpoint, other types of cable barrier (such as Test Level 4 or newly tested designs) should be used*

Update: Implementation of this recommendation is in progress. Given the testing and development that is underway for cable barriers on 4H:1V slopes, we anticipate that WSDOT will adopt these barriers for new installations. In addition, we are working with manufacturers on a retrofit design for existing installations. At that time, WSDOT will have to determine the priority of this work compared to other safety improvements.

WSDOT's use of barriers that are tested for 4H:1V slopes will make cable barrier placement less critical.

- **Installation locations**

  In choosing installations for both cable median barrier and concrete median barrier, WSDOT should consider crash history as well as median characteristics and traffic volumes, as recommended by Dr. Ray.

  Update: For this report, WSDOT evaluated all of the cable median barrier locations as recommended. Based on this evaluation, there were nine locations where the rate of cross-median collisions exceeded the 0.75 collisions per 100 million vehicle miles threshold suggested by Dr. Ray. One of these sections did not meet the minimum section length (two miles) that Dr. Ray suggested. Four other sections did not meet the minimum exposure (100 million vehicle miles) for the barrier. In both of these cases, the rate may be distorted by the short length and low exposure. The remaining four sections are as follows:

  I-5, Marysville: This section has a cross-median collision rate of 0.77, which is just above the threshold of 0.75. This section was studied extensively in 2007 and, as a result, concrete barrier was proposed. (See page 27 for more details on this project.)

  I-5, Puyallup River to Fife: This section has a cross-median collision rate of 0.89. There were two cross-median collisions in this section in 2007. This section is being widened to add an HOV lane in the median starting in 2009, and concrete median barrier will be installed at that time.

  I-90, George to Moses Lake: In the June 2007 report, this section had a cross-median collision rate of 3.65 after the installation of cable median barrier. This was based on three cross-median incidents, none of which involved a collision with a vehicle in the opposing direction. In 2007 there were no additional cross-median incidents in this section and, as a result, the rate for this section decreased to 2.14. As noted in our June 2007 report, the short time exposure and the relatively low traffic volumes may have distorted the rate. The rate decreased significantly. In reality, the daily traffic volume on this highway segment is well below the threshold that Dr. Ray identifies in his criteria for site characteristics. However, we will continue to monitor this location.

  I-90, Spokane: In the June 2007 report, this section had a cross-median collision rate of 1.15. This was based on three cross-median incidents, one of which involved a collision with a vehicle in the opposing direction. In our analysis for this update, this section had a rate of 1.48. In 2007 there were an additional three cross-median incidents within the limits of the cable barrier. Two of these did not result in an injury and the other resulted in an evident injury. This section is being evaluated further to determine if any modifications would be cost-effective.

- **Cable median barrier maintenance and inspection**

  Make routine inspections of in-service cable median barrier systems.

  Update: All wedge connections in low-tension cable systems were inspected in 2007. Maintenance crews continue to inspect these connections as repairs are made following cable hits.

  As noted previously, WSDOT has contracted with Texas Transportation Institute to develop a new design that does not use the wedge connection. This research will be completed in 2008.

- **Tracking**

  Improve WSDOT's tracking procedures.

  Update: All cable median barrier repairs are reported to WSDOT's Headquarters Design Office. In addition, the Washington State Patrol has begun reporting cable barrier collisions to the WSDOT as they happen. This data was used in the development of the information on page 9 of this report.

- **Monitoring Performance**

  Continue to monitor the performance of all cable median barrier.

  Update: WSDOT has continued to monitor the performance of the cable median barrier, and this update summarizes the performance through 2007. WSDOT will prepare another supplement in 2009 that includes all of the 2008 data.

- **Research and development of cable median barrier systems**

  Support and participate in research on the conditions that promote median crossovers.

  Update: Department of Transportation staff for Washington, Wisconsin, and Minnesota developed a research problem statement, "Investigation of Contributing Factors Associated with Cross-Median Crashes and Identification of Appropriate Countermeasures," that was selected for funding as an NCHRP (National Cooperative Highway Research Program) project. A researcher has not yet been selected for this project and it will most likely start in the spring of 2009.

- **Revised crash test criteria**

  Urge adoption of the revised crash test criteria.

  Update: The revised crash test criteria, which will be called MASH 2008 (Manual for Assessing Safety Hardware), has been submitted to the states for balloting and is expected to be adopted by the end of 2008. The primary change that will lead to modifications in barrier design is the adoption of crash-testing criteria for larger pickup trucks (those with a higher bumper). Many manufacturers and researchers have begun using these new criteria.

- **Additional testing**

  Urge additional testing of cable median barrier on slopes.

  Update: As mentioned previously, WSDOT has been encouraging the testing of barrier on slopes and it is expected that new designs will be used in the future.